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Hughes

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(54) **RULE BASED EXTENSIBLE AUTHENTICATION**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 838 days.

This patent is subject to a terminal disclaimer.

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(51) **Int. Cl.**
H04L 29/06 (2006.01)

(52) **U.S. Cl.**
CPC ***H04L 63/105*** (2013.01)

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CPC H04L 63/08; H04L 63/205; H04L 63/10; H04L 63/105
USPC 726/4, 5, 11, 13, 6, 7, 8; 713/154, 155, 713/153
See application file for complete search history.

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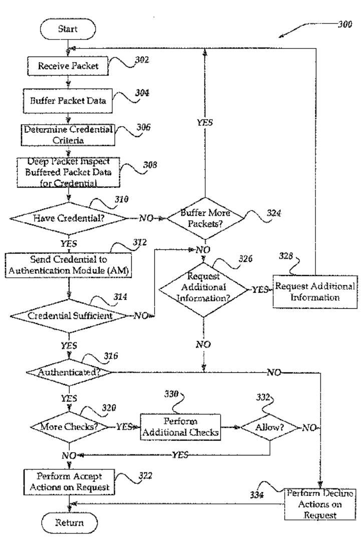
(57) **ABSTRACT**

A system, apparatus, and method are directed to managing access to a resource using rule-based deep packet extractions of a credential. A network device, such as a traffic management device, is situated between a client device and a server device. When the client device sends a request for a resource, the request is intercepted by the network device. The network device may employ a multi-layer deep packet extraction of the credential from the request. The network device may then use the credential to determine whether the request enabled to access the resource. Based, in part, on a variety of rules, the network device may deny access, enable access, route the request to a different server, or the like. In one embodiment, the network device may receive a rule from another device that directs the network device to request a different credential.

20 Claims, 3 Drawing Sheets



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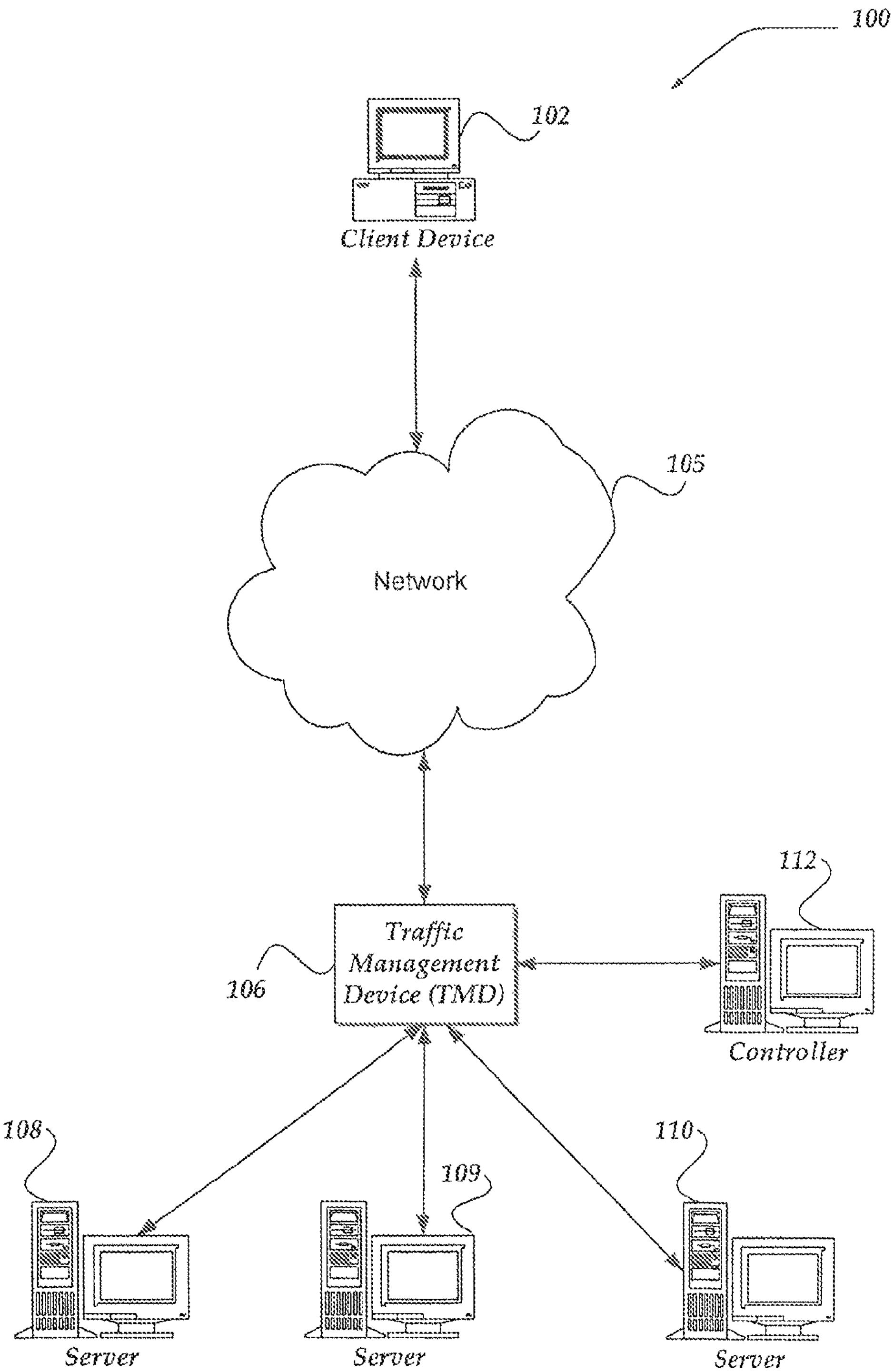
100
102
Client Device
105
Network
Traffic Management Device (TMD)
106
112
Controller
108
109
110
Server
Server
Server

FIG. 1

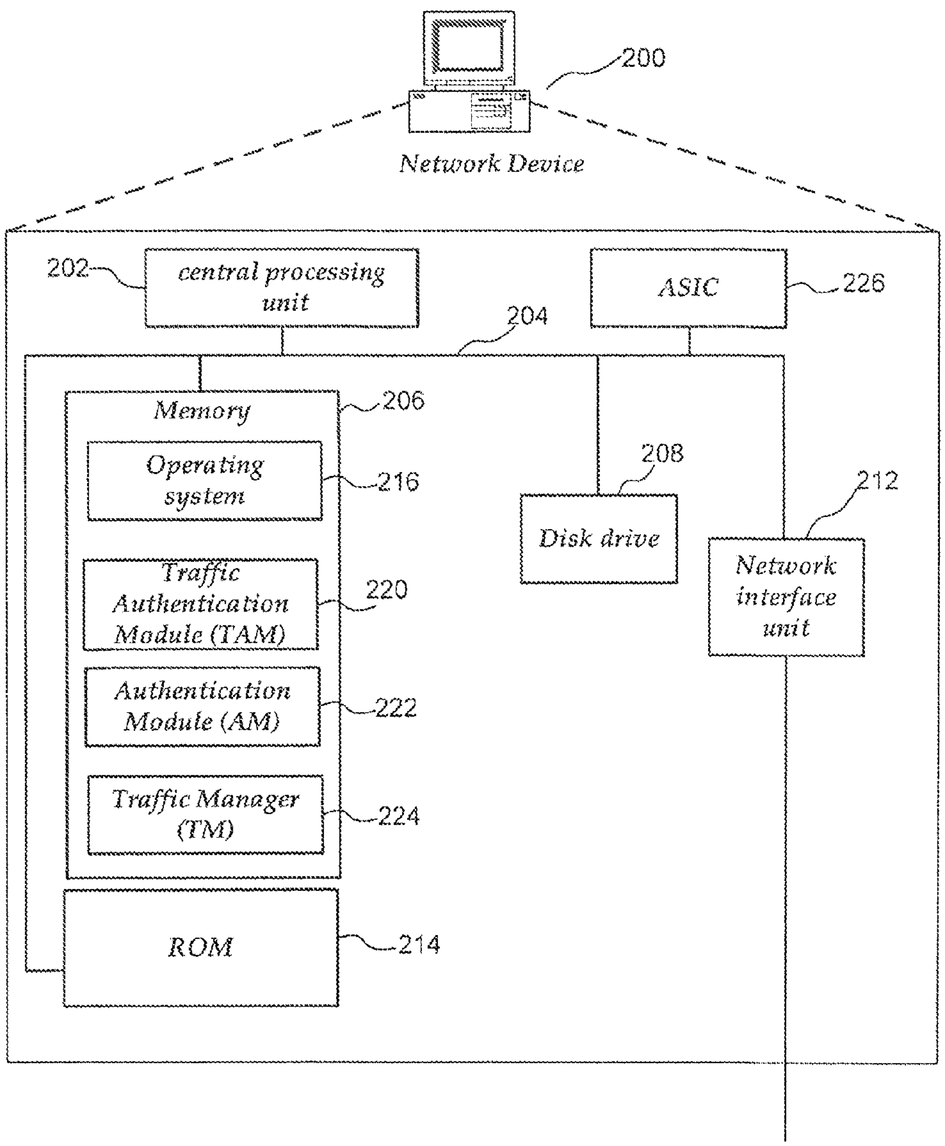
200
Network Device
202
central processing unit
ASIC
226
204
Memory
206
Operating system
216
208
Disk drive
212
Network interface unit
Traffic Authentication Module (TAM)
220
Authentication Module (AM)
222
Traffic Manager (TM)
224
ROM
214

FIG. 2

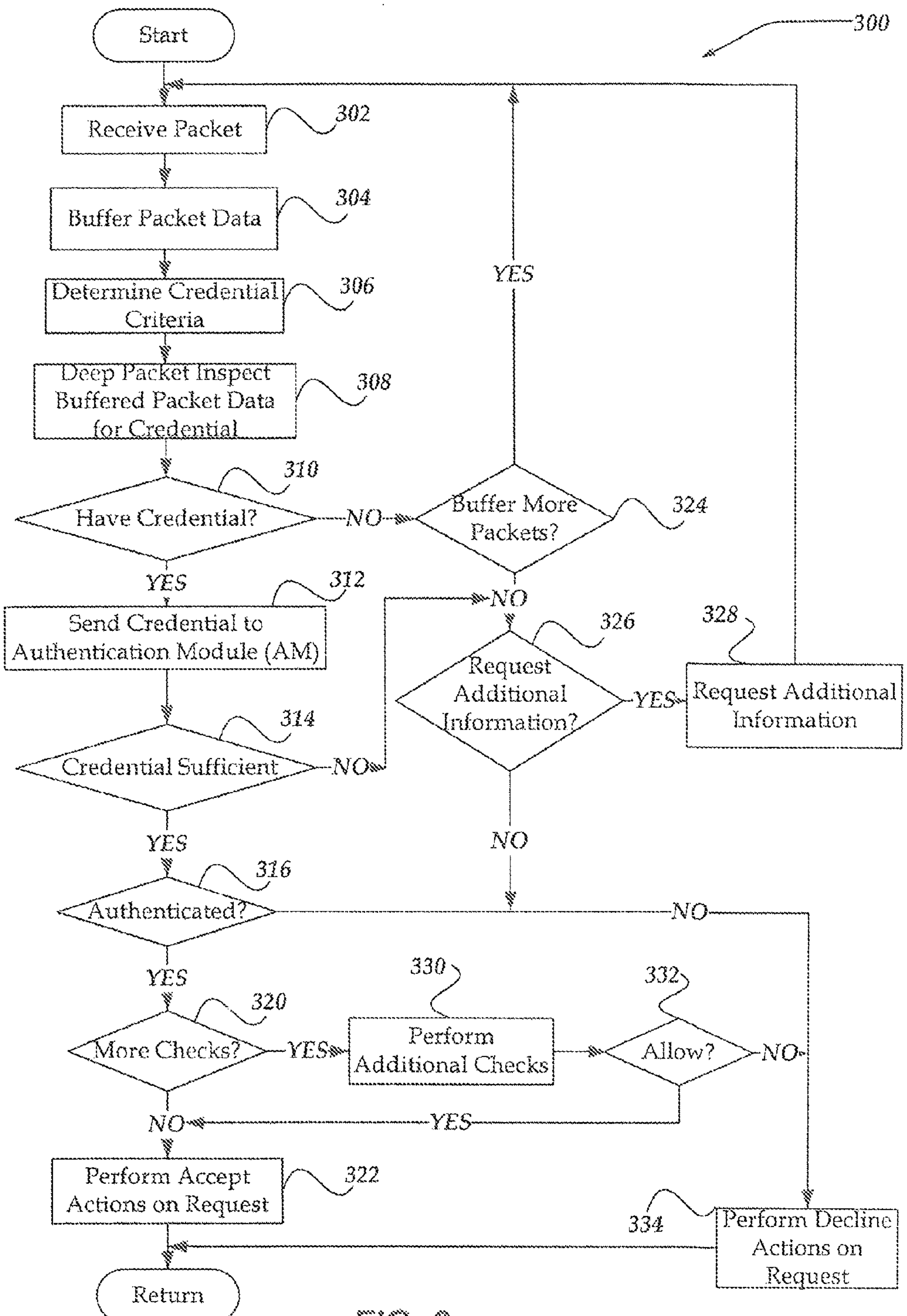
300
Start
Receive Packet
302
Buffer Packet Data
304
Determine Credential Criteria
306
Deep Packet Inspect Buffered Packet Data for Credential
308
Have Credential?
310
NO
Buffer More Packets?
324
YES
YES
Send Credential to Authentication Module (AM)
312
NO
Request Additional Information?
326
YES
Request Additional Information
328
Credential Sufficient
314
NO
YES
NO
Authenticated?
316
NO
YES
More Checks?
320
YES
Perform Additional Checks
330
Allow?
332
NO
NO
YES
Perform Accept Actions on Request
322
Perform Decline Actions on Request
334
Return

FIG. 3

RULE BASED EXTENSIBLE AUTHENTICATION

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a Continuation Application of U.S. Pat. No. 8,418,233 entitled "Rule Based Extensible Authentication," filed on Oct. 24, 2005, and further claims the benefit of U.S. Provisional Application Ser. No. 60/703,624 entitled "Rule Based Extensible Authentication," filed on Jul. 29, 2005, the benefit of the earlier filing dates of which is hereby claimed under 35 U.S.C. §119 (e) and §120 and which are each further incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates generally to communications security, and more particularly, but not exclusively, to a system and method for managing rule based authentication that is arranged to be extensible.

BACKGROUND OF THE INVENTION

Networked computing is becoming increasingly more important to the success of many businesses today. Networked computers provide access to a wide variety of information and services ranging from games, blog sites, and merchant websites, to mission critical services. Many of these networked computers involve server devices that are configured to perform a plurality of other activities along with their intended business related activity. Some of these other activities may include managing data redundancy, failover services, managing connections, as well as managing security activities. As the non-business related activities managed by a server device increases, the server device may become overloaded, resulting in reduced performance, effectivity, and/or throughput. Therefore, it may be desirable to minimize the amount of non-business related activities performed by a server device. Thus, it is with respect to these considerations, and others, that the present invention has been made.

BRIEF DESCRIPTION OF THE DRAWINGS

Non-limiting and non-exhaustive embodiments of the present invention are described with reference to the following drawings. In the drawings, like reference numerals refer to like parts throughout the various figures unless otherwise specified.

For a better understanding of the present invention, reference will be made to the following Detailed Description of the Invention, which is to be read in association with the accompanying drawings, wherein:

FIG. **1** shows a functional block diagram illustrating one embodiment of an environment for practicing the invention;

FIG. **2** shows one embodiment of a network device that may be included in a system implementing the invention; and

FIG. **3** illustrates a logical flow diagram generally showing one embodiment of a process for managing access to a resource using deep packet credential extractions, in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention now will be described more fully hereinafter with reference to the accompanying drawings, which form a part hereof, and which show, by way of illustration, specific exemplary embodiments by which the invention may be practiced. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Among other things, the present invention may be embodied as methods or devices. Accordingly, the present invention may take the form of an entirely hardware embodiment, an entirely software embodiment or an embodiment combining software and hardware aspects. The following detailed description is, therefore, not to be taken in a limiting sense.

Throughout the specification and claims, the following terms take the meanings explicitly associated herein, unless the context clearly dictates otherwise. The phrase "in one embodiment" as used herein does not necessarily refer to the same embodiment, though it may. As used herein, the term "or" is an inclusive "or" operator, and is equivalent to the term "and/or," unless the context clearly dictates otherwise. The term "based on" is not exclusive and allows for being based on additional factors not described, unless the context clearly dictates otherwise. In addition, throughout the specification, the meaning of "a," "an," and "the" include plural references. The meaning of "in" includes "in" and "on."

As used throughout this application, including the claims, SSL refers to SSL, TLS, and all secure communications protocols derived therefrom. The SSL protocol is described in Netscape

Communications Corp, Secure Sockets Layer (SSL) version 3, (November 1996), available from Netscape. The TLS protocol is derived from SSL, and is described in Dierks, T., and Allen, C., "The TLS Protocol Version 1.0," RFC 2246 (January 1999), is available from The Internet Engineering Task Force (IETF). The SSL Protocol may employ a certificate. In one embodiment, the certificate is an X.509 certificate, such as those described in Request for Comments (RFC) 2459 available from the IETF.

The term 'credential' as used herein refers to data that may be verified when presented in an authentication transaction. Credentials typically are bound in some way to an entity, such as a client, server, user, or the like. Credentials may also be used to enable authorization and/or access rights for the bound entity.

In this specification, the term "client" refers to a computer's general role as a requester of data or services, and the term "server" refers to a computer's role as a provider of data or services. In general, it is possible that a computer can act as a client, requesting data or services in one transaction and act as a server, providing data or services in another transaction, thus changing its role from client to server or vice versa.

Briefly stated, the present invention is directed towards a system, method, and apparatus for managing access to a resource using rule-based deep packet credential extractions. A network device, such as a traffic management device, is situated between a client device and a server device within a networking infrastructure. When the client device sends a request for a resource towards the server device, the request may be intercepted by the network device. The network device may employ a multi-layer deep packet inspection to extract information from the request and/or a related network packet flow useable to generate a credential. In one embodiment, the credential includes a username/password combination. In another embodiment, the credential may include a digital certificate. In one embodiment, the deep packet extraction may be over several network packets. The network device may then employ various modules to determine whether the request is authentic and/or authorized to access the resource. In one embodiment, the modules include a Pluggable Authentication Module (PAM). In another embodiment, the modules may include an Apache Authentication/Authorization/Access (AAA) module. Based, in part, on a variety of rules, the network device may deny access, may provide access to the resource, or the like. Additional checks for access may also be employed to further increase access protection through the use of a rule scripting language. In one embodiment, the network device may receive a rule from another device that directs the network device to request different credential information. In one embodiment, the network device may employ the results of the determination to route the request to another server device. Moreover, the network device may also provide the authentication information to another server device to enable access to additional resources.

Illustrative Operating Environment

FIG. **1** illustrates one embodiment of an environment in which the invention may operate. However, not all of these components may be required to practice the invention, and variations in the arrangement and type of the components may be made without departing from the spirit or scope of the invention.

As shown in the figure, system **100** includes client device **102**, network **105**, traffic management device (TMD) **106**, controller **112**, and servers **108-110**. Client device **102** is in communication with TMD **106** through network **105**. TMD **106** is in further communication with servers **108-110**, and controller **112**. Although not shown, TMD **106** may be in communication with servers **108-110** through a network infrastructure that is similar to network **105**. For example, in one embodiment, TMD **106**, controller **112**, and servers **108-110** might reside within a common local area network type of infrastructure, although the invention is not constrained to such a configuration.

Generally, client device **102** may include virtually any computing device capable of connecting to another computing device and receiving information. Such devices may also include portable devices such as, cellular telephones, smart phones, display pagers, radio frequency (RF) devices, infrared (IR) devices, Personal Digital Assistants (PDAs), handheld computers, wearable computers, tablet computers, integrated devices combining one or more of the preceding devices, and the like. Client device **102** may also include other computing devices, such as personal computers, multiprocessor systems, microprocessor-based or programmable consumer electronics, network devices, and the like. As such, client device **102** may range widely in terms of capabilities and features. For example, a client device configured as a cell phone may have a numeric keypad and a few lines of monochrome LCD display on which only text may be displayed.

In another example, a web-enabled client device may have a touch sensitive screen, a stylus, and several lines of color LCD display in which both text and graphics may be displayed. Moreover, the web-enabled client device may include a browser application enabled to receive and to send wireless application protocol messages (WAP), and/or wired application messages, and the like. In one embodiment, the browser application is enabled to employ HyperText Markup Language (HTML), Dynamic HTML, Handheld Device Markup Language (HDML), Wireless Markup Language (WML), WMLScript, JavaScript, EXtensible HTML (xHTML), Compact HTML (CHTML), and the like, to display and send a message.

Client device **102** also may include at least one client application that is configured to receive content from another computing device. The client application may include a capability to provide and receive textual content, graphical content, audio content, alerts, messages, and the like. Moreover, client device **102** may be further configured to communicate a message, such as through a Short Message Service (SMS), Multimedia Message Service (MMS), instant messaging (IM), internet relay chat (IRC), mIRC, Jabber, and the like, between another computing device, and the like.

In one embodiment, client device **102** may be configured such that an end-user may operate the computing device to make requests for data and/or services from other computers on the network. In one embodiment, client device **102** may employ a network interface unit (sometimes called a transceiver), such as described below, to communicate information with another computing device. Often, the requested data resides in computing devices such as servers **108-110**. In one embodiment, client device **102** is a computing device that is not operated by an end-user.

Network **105** is configured to couple one computing device with another computing device. Network **105** may be enabled to employ any form of computer readable media for communicating information from one electronic device to another. Also, network **105** can include the Internet in addition to local area networks (LANs), wide area networks (WANs), direct connections, such as through a universal serial bus (USB) port, other forms of computer-readable media, or any combination thereof. On an interconnected set of LANs, including those based on differing architectures and protocols, a router acts as a link between LANs, enabling messages to be sent from one to another. Also, communication links within LANs typically include twisted wire pair or coaxial cable, while communication links between networks may utilize analog telephone lines, full or fractional dedicated digital lines including T1, T2, T3, and T4, Integrated Services Digital Networks (ISDNs), Digital Subscriber Lines (DSLs), wireless links including satellite links, or other communications links known to those skilled in the art. Furthermore, remote computers and other related electronic devices could be remotely connected to either LANs or WANs via a modem and temporary telephone link.

Network **105** may further include any of a variety of wireless sub-networks that may further overlay stand-alone ad-hoc networks, and the like, to provide an infrastructure-oriented connection. Such sub-networks may include mesh networks, Wireless LAN (WLAN) networks, cellular networks, and the like. Network **105** may also include an autonomous system of terminals, gateways, routers, and the like connected by wireless radio links, and the like. These connectors may be configured to move freely and randomly and organize themselves arbitrarily, such that the topology of network **105** may change rapidly.

Network **105** may further employ a plurality of access technologies including 2nd (2G), 2.5, 3rd (3G), 4th (4G) generation radio access for cellular systems, WLAN, Wireless Router (WR) mesh, and the like. Access technologies such as 2G, 3G, and future access networks may enable wide area coverage for mobile devices with various degrees of mobility. For example, network **105** may enable a radio connection through a radio network access such as Global System for Mobile communication (GSM), General Packet Radio Services (GPRS), Enhanced Data GSM Environment (EDGE), Wideband Code Division Multiple Access (WCDMA), CDMA2000, and the like. In essence, network **105** may include virtually any wired and/or wireless communication mechanisms by which information may travel between one computing device and another computing device, network, and the like.

Additionally, communication media typically embodies computer-readable instructions, data structures, program modules, or other data in a modulated data signal such as a carrier wave, data signal, or other transport mechanism and includes any information delivery media. The terms "modulated data signal," and "carrier-wave signal" includes a signal that has one or more of its characteristics set or changed in such a manner as to encode information, instructions, data, and the like, in the signal. By way of example, communication media includes wired media such as twisted pair, coaxial cable, fiber optics, wave guides, and other wired media and wireless media such as acoustic, RF, infrared, and other wireless media.

Servers **108-110** may include any computing device capable of communicating packets with client computer **102**. Each packet may convey a piece of information. A packet may be sent for handshaking, i.e., to establish a connection or to acknowledge receipt of data. The packet may include information such as a request, a response, or the like. Generally, packets received by servers **108-110** will be formatted according to TCP/IP, but they could also be formatted using another transport protocol, such as User Datagram Protocol (UDP), Internet Control Message Protocol (ICMP), NETbeui, IPX/SPX, token ring, and the like. Moreover, the packets may be communicated between servers **108-110**, TMD **106**, and client device **102** employing HTTP, HTTPS, and the like.

In one embodiment, servers **108-110** are configured to operate as a website server. However, servers **108-110** are not limited to web servers, and may also operate a messaging server, a File Transfer Protocol (FTP) server, a database server, a directory server, lightweight directory access protocol (LDAP) server, a content server, and the like. Additionally, each of servers **108-110** may be configured to perform a different operation. Thus, for example, server **108** may be configured as a messaging server, while server **109** is configured as a database server. Moreover, while servers **108-110** may operate as other than a website, they may still be enabled to receive an HTTP communication.

Devices that may operate as servers **108-110** include personal computers desktop computers, multiprocessor systems, microprocessor-based or programmable consumer electronics, network PCs, servers, and the like.

TMD **106** may include virtually any device that manages network traffic. Such devices include, for example, routers, proxies, firewalls, load balancers, cache devices, devices that perform network address translation, any combination of the preceding devices, and the like. TMD **106** may be implemented using one or more personal computers, servers, multiprocessor systems, microprocessor-based or programmable consumer electronics, network PCs, radio frequency (RF) devices,. infrared (IR) devices, integrated devices combining one or more of the preceding devices, and the like. Such devices may be implemented solely in hardware or in hardware and software. For example, such devices may include some application specific integrated circuits (ASICs) coupled to one or more microprocessors. The ASICs may be used to provide a high-speed switch fabric while the microprocessors may perform higher layer processing of packets. An embodiment of a network device that could be used as TMD **106** is network device **200** of FIG. **2**, configured with appropriate software. The BIG-IP® family of traffic managers, by F5 Networks of Seattle, Wash., are examples of TMDs.

TMD **106** may be configured to control a flow of data packets delivered to and forwarded from an array of servers, such as servers **108-110**. TMD **106** may direct a request for a resource to a particular server based on network traffic, network topology, capacity of a server, content requested, an authentication, or authorization status, and a host of other traffic distribution mechanisms. TMD **106** may receive data packets from and transmit data packets to the Internet, an intranet, or a local area network accessible through another network. TMD **106** may recognize packets that are part of the same communication, flow, and/or stream and may perform special processing on such packets, such as directing them to the same server so that state information is maintained. TMD **106** also may support a wide variety of network applications such as web browsing, email, telephony, streaming multimedia and other traffic that is sent in packets.

TMD **106** may receive a request for access to a resource from client device **102**. TMD **106** may be configured, in part, to determine whether the end-user of client device **102** is authentic and/or authorized to access the resource. TMD **106** may determine whether the end-user is authorized to access the resource based on a variety of conditions, including, but not limited to a type of client device being employed by the end-user; the software installed on the client and its security parameters; a time of day of the request; a type of request such as whether the request is a read-only request, a modify request, a delete request; a number of times the end-user has requested access to the resource; a number of times the request has been accessed over a period of time, total number of aggregate requests for the resource; or the like.

In any event, TMD **106** may then, based in part, on this determination select a server from servers **108-110** to receive the request, deny access to the request, flag the request for additional processing or special treatment such as verbose logging, intrusion detection analysis, or virtually any of a variety of other actions. For example, based on the request, and/or a client authorization, a determination may be made as to whether to secure a network connection, or the mechanism, including the level of security, to use in securing the network connection. This may be done, example, by causing the communication with the server to be encrypted using SSL or the like, causing the communication with the client to be encrypted using SSL (and STARTTLS if appropriate), or by causing a higher grade encryption to be used.

TMD **106** may determine authentication, authorization, access permissions, or the like by performing a deep packet inspection and/or extraction from a received packet or packets associated with the request. Deep packet inspections enable extractions of various information in either a passive mode or an active mode with respect to interacting with the client itself, with TMD **106** using the extracted information to enable access to a resource, direct the traffic towards a resource, or even deny access. Active mode in this respect uses a query mechanism, such as described in this specification, to request information from the client.

Deep packet inspection and the generation of criteria is described in more detail in U.S. patent application Ser. No. 10/385,790, filed Mar. 10, 2003, and entitled "Method and System for Managing Network Traffic," which is hereby incorporated by reference. Briefly, however, deep packet inspection enables TMD **106** to examine contents of a packet or packets associated with virtually any layer of the OSI layered protocol, above the network layer (layer 3). For example, deep packet inspections enable TMD **106** to examine an HTTP request, an HTTPS request, Secure Socket Layer (SSL) protocol data, a Session Initiation Protocol (SIP) request, a request for an

HTML page, a request including a Uniform Resource Locator (URL), eXtensible Markup Language (XML) content, information that identifies a user, a cookie, application specific information, or the like. Deep packet inspection may include recognizing when a request spans two or more packets and examining content that spans multiple packets. It may, for example, include extracting and examining data within an HTTP header or data within HTTP content.

Moreover, inspection may include examining a variety of credential information, including FTP passwords, XML stream authenticators, database authenticators, form-based authenticators, application-cached credentials, encrypted cookies, fields within a digital certificate. In one embodiment, credential information may be received in the header or data portions of a single TCP SYN packet, or an HTTP request. Credential information may be received in packets exchanged during an SSL handshake. In another embodiment, credential information may be obtained by employing a combination of authentication mechanisms, authentication sources, credential types, or the like.

In one embodiment, a deep packet inspection mechanism provides syntax for a set of rules that enable the creation of event criteria for making various access and/or routing determinations based, in part, on data within virtually any TCP, UDP, or IP communication, or the like, including combinations of communications employing one or more network protocols. The event criteria may include conditional commands and event control instructions that enable one to perform actions based on specified conditions.

The rule syntax provides the ability to examine portions of data, such as may be described by offsets and lengths of data, with respect to the TCP, UDP, HTTP payload, or the like. This examination includes supporting arbitrary expressions, including full access to protocol headers, such as TCP, as well as TCP/UDP content, and application layer data of the OSI layered protocol. For example, event criteria may include a rule command, "HTTP::cookie <name>," that indirectly causes received data to be buffered. In processing this reference, TMD **106** may buffer more than one packet, to extract the data corresponding to the HTTP cookie. In one embodiment, the number of packets that are buffered is restricted to the number of packets required to identify the referenced data. In another embodiment, the number of packets that are buffered is selectable based on a number of packets, number of bits, a request to access one or more symbolic variables, and the like.

The rule syntax further enables examination of data from a first layer of the OSI layered protocol, and a second layer of the OSI layered protocol of the packet, where the first and second layers are from any of the OSI layers above the network layer of the OSI layered protocol. The rule syntax enables formation of event criteria that includes examination of data from at least one layer of the OSI layered protocol, at least two different layers, and virtually any combination of data from one or more layers.

Moreover, the rule syntax may be implemented using virtually any programming, and/or scripting language that enables dynamic rule creations, including the Tool Command Language (Tcl) scripting language, the Aho Weinberger Kernighan (AWK) language, the Practical Extraction Report Language (PERL), or the like.

In one embodiment, the rule syntax enables access to one or more symbolic variables. Some of the variables may represent data that are available in the IP packet header, HTTP protocol header, or the like. The following table illustrates one embodiment of a non-exhaustive set of rule commands that are available to obtain such credential data. Moreover, the following table is not intended to be restrictive, and other sets of rule commands may be employed without departing from the scope or spirit of the invention.

HTTP::header <name>	Returns value of the http header named <name>.
HTTP::username	Returns the user name part of the HTTP basic authorization.
HTTP::password	Returns the password part of the HTTP basic authorization.
HTTP::method	Returns the type of HTTP request method.
HTTP::version	Get the HTTP version of the request or response.
HTTP::uri	Get the complete uri of the request.
HTTP::payload	Returns the content collected so far by HTTP::collect.
HTTP::cookie <name>	Gets the cookie of the given name.
HTTP::cookie decrypt <name> <pass-phrase> <data>	Decrypt the cookie value for the given cookie using a key generated from the pass phrase.
SSL::cert <index>	Returns the index-th X509 SSL certificate in the peer certificate chain, where Index is a value greater than or equal to zero. A value of zero denotes the first certificate in the chain, a value of one is the next, etc.
SSL::cert issuer <index>	Returns the issuer certificate of the index-th X509 SSL certificate in the peer certificate chain, where index is a value greater than or equal to zero. A value of zero may denote the first certificate in the chain, a value of one is the next, etc.
SSL::cipher name	Returns the current SSL cipher name using for format of OpenSSL's SSL_CIPHER_get_name( ).
SSL::cipher version	Returns the current SSL cipher version using for format of OpenSSL's SSL_CIPHERget_version( ).
SSL::cipher bits	Returns the number of secret bits used by the current SSL cipher using for format of OpenSSL's SSL_CIPHER_get_blts( ).
TCP::remote_port	Returns the current context's remote TCP port/service number.
TCP::local_port	Returns the current context's local TCP port/service number.
TCP::client_port	Returns the client's TCP port/service number.
TCP::server_port	Returns the server TCP port/service number.
TCP::payload	Returns the collected TCP data content.
UDP::remote_port	Returns the current context's remote UDP port/service number.
UDP::local_port	Returns the current context's local UDP port/service number.
UDP::clientport	Returns the client's UDP port/service number.
UDP::server_port	Returns the server UDP port/service number.
UDP::payload	Returns the current UDP payload content.

To employ the event criteria generated from the rule syntax, one typically identifies the element or elements, in a packet to be used. This may be achieved, for example, by employing a filter on the output of tcpdump, or employing a network protocol analyzer to examine packets on the wire, and the like. Tcpdump is a utility used for examining header fields within packets, and is described in RFC 1470, available from the IETF. However, the invention is not so limited and virtually any mechanism may be employed, without departing from the scope of the invention. Moreover, TMD **106** may employ a process substantially similar to that described below in conjunction with FIG. **3** to perform at least some of its actions described above.

Controller **112** may include virtually any networked device that is configured to provide rule syntax and other instructions to TMD **106** for use in managing access to a resource. Controller **112** may for example, include security devices, such as intrusion detection or prevention devices, firewalls, proxies, gateways, system administration devices, or the like. Devices that may operate as controller **112** include personal computers desktop computers, multiprocessor systems, microprocessor-based or programmable consumer electronics, network PCs, servers, and the like.

Controller **112** may be configured, for example, to determine which one or more credentials should be requested, a level of security to be enforced, or the like. Controller **112** may make any of these determinations in response to events that occur or conditions that are met. Controller **112** may, for example, detect a suspicious activity, and send a request, one or more rules, or the like, to TMD **106** to vary its level of credential checks. Controller **112** may provide such directions automatically, or even through a manual interaction. The conditions that result in Controller **112** sending instructions to the TMD **106** may be the occurrence of a single event or multiple events occurring over a period of time. The conditions may include the type, content, or quantity of incoming requests. The conditions may include status conditions of one or more servers. The condition may include any one or more of these or other criteria being met.

Controller **112** may also request that at least a portion of a credential be provided to another device, such as servers **108-110**, or even controller **112**. The other device may then employ the provided portion of the credential for any of a variety of reasons, including providing access to another resource, enable logging of events, or the like. The other device may provide Controller **112** with information that is used in making authentication and authorization decisions.

An administrator may employ the mechanisms of the invention by creating rules described herein and installing the rules on controller **112**. In one embodiment, an administrator installs at least a portion of the rules on TMD **106**. An administrator may employ a variety of mechanisms to modify configured rules.

The invention is not constrained to providing requests and the like to TMD **106** through controller **112**, however. Thus, TMD **106** may also receive directions from virtually any device, including servers **108-110**, or the like. For example, TMD **106** may receive rules, or other criteria from at least one server, indicating which authentication policy, method, and/or credentials to employ. TMD **106** may receive rules or other criteria from another TMD, wherein the other TMD is on the same LAN as TMD or is accessed across network **105**. Such communications may be performed in an out-of-band process, or even in-band, as part of a process that TMD **106** may employ in determining access to a resource.

Illustrative TMD Environment

FIG. **2** shows an exemplary network device **200** that may operate as TMD **106** of FIG. **1**. It will be appreciated that not all components of network device **200** are illustrated, and that network device **200** may include more or less components than those shown in FIG. **2**.

As illustrated in FIG. **2**, network device **200** includes a central processing unit (CPU) **202**, mass memory, and a network interface unit **212** connected via a bus **204**. Network interface unit **212** includes the necessary circuitry for connecting network device **200** to various networks, including network **105** of FIG. **1**, and is constructed for use with various communication protocols including the TCP/IP and UDP/IP protocol. Network interface unit **212** may include or interface with circuitry and components for transmitting messages and data over a wired and/or wireless communications medium. Network interface unit **212** is sometimes referred to as a transceiver, Network Interface Card (NIC), or the like.

In one embodiment, network device **200** includes one or more Application Specific Integrated Circuit (ASIC) chip **226**. Although not illustrated, in one embodiment, ASIC chip **226** may reside on a daughter board rather then being connected to bus **204**. As shown in FIG. **2**, network interface unit **212** may connect to bus **204** through at least one ASIC chip. ASIC chip **226** can include logic that enables at least some of the actions of network device **200**. For example, in one embodiment, ASIC chip **226** can be employed to perform packet processing functions on incoming and/or outgoing packets. In one embodiment, network device **200** includes one or more field-programmable gate arrays (FPGA) (not shown), instead of, or in addition to, ASIC chip **226**.

A number of actions for the network device can be performed by ASIC chip **226**, an FPGA, CPU **202** with instructions stored in memory, or any combination of actions performed by the ASIC chip, FPGA, and CPU.

Computer storage media may include volatile and nonvolatile, removable and non-removable media implemented in any method or technology for storage of information, such as computer readable instructions, data structures, program modules or other data. Examples of computer storage media include RAM **206**, ROM **214**, EEPROM, flash memory and/or any other memory architecture, CD-ROM, digital versatile disks (DVD) and/or any other optical storage, magnetic cassettes, magnetic tape, magnetic disk storage and/or any other magnetic storage devices, and/or any other medium that can store information that can be accessed by a computing device.

Network device **200** may also include an input/output interface (not shown) for communicating with external devices or users.

Network device **200** can be implemented as one or more "blades" where the term "blade" refers to one of multiple electronic circuit boards or cards that are installed in a hardware chassis with a backplane. An exemplary blade may include one or more processors, volatile and non-volatile memory, interfaces suitable for communicating information to and from the blade, and other components for enabling the operation of one or more applications. A blade may also include a specialized interface for the backplane and other interfaces, such as a USB port, FIREWIRE port, serial port, RF interface, IR interface, Ethernet interface, IDE controller, and the like. An application running on a blade may employ any of these interfaces to communicate information to other applications running on other blades and/or devices coupled to the blade server. Network device **200** can also be implemented as a combination of blades and additional components in the chassis.

The mass memory generally includes random access memory ("RAM") **206**, read-only memory ("ROM") **214**, and one or more permanent mass storage devices, such as hard disk drive **208**. The mass memory stores operating system **216** for controlling the operation of network device **200**. The operating system **216** may comprise an operating system such as UNIX, LINUX™, or Windows™. In one embodiment, the mass memory may store program code and data for implementing traffic manager (TM) **224**, authentication module (AM) **222**, and traffic authentication module (TAM) **220**.

TM **224** may be configured to receive a request for a resource and send the request to TAM **220** for authentication to proceed, and/or additional instructions on how to handle the request. Based on the authentication response and/or the additional instructions, TM **224** may direct the request to a server, deny the request, provide a message to the requestor, or the like. TM **224** may, for example, direct the request based on a variety of criteria, including a load-balancing mechanism, a type of request, or the like.

TAM **220** may receive a request for a resource from TM **224**. TAM **220** may then perform a deep-layer inspection of the request, including at least one packet associated with the request, to extract a credential. In one embodiment, the credential includes a username and/or a password. In another embodiment, the credential includes a digital certificate or signature. In yet another embodiment, the credential includes a Kerberos ticket. In yet another embodiment, the credential includes a Security Association Markup Language assertion. In yet another embodiment, the credential includes an ephemeral or two-factor security token such as an RSA SecurID. In yet another embodiment, the credential includes an IPSec security association. However, TAM **220** is not constrained to extracting merely credential information, and TAM **220** may extract virtually any information from the request, or even subsequent communications from a requestor. Moreover, TAM **220** may extract information from virtually any OSI layer above the network layer in the request or subsequent communications.

TAM **220** may further determine that the request and/or subsequent communications do not include sufficient information to make an authentication, authorization, and/or access determination, and therefore, TAM **220** may enable communications with the requestor seeking the additional information. In one embodiment TAM **220** may enable a webpage, form, or similar query mechanism to be employed to request the additional information. The request may be automatically answered, for example, by the client device, or require an input from an end-user of the client device. Automated answers may include, for example, an HTTP authentication credential cached by the client device's web browser, a client certificate such as an SSL certificate, FTP login credentials, or the like, or a field that may be pre-populated with information that might be cached by the client device.

TAM **220** may then provide the credential information to AM **222** for an authentication, authorization, and/or access determination to be performed. In one embodiment, TAM **220** may provide the credential information to AM **222** through a series of communications, such as a series of questions and responses, or the like.

TAM **220** may also receive a request from another device or component to vary what information may be employed for use in a credential, and/or what other access determinations may be performed. Thus, for example, TAM **220** may receive a request to increase a level of security. For example, one level of security may use a username/password in a credential, while a higher level of security may use a digital certificate either instead of, or in addition to, the username/password. Another request may specify that a second password is to be used in addition to a username/password. Moreover, TAM **220** may be arranged to request additional information and make additional access determination based on the credential and/or additional information. Thus, in one embodiment, TAM **220** may receive an authentication/authorization, access determination from AM **222**, but proceed to perform additional determinations based on additional rules. For example, a request may be authorized based on a username/password, but TAM **220** may extract information about the client such as whether it is another website, a user, other the like, and make additional access determinations. A request specifying a change in the credential information to be used may further designate the scope of the change. The scope of the change refers to the extent of when the new credential specification is to be used. The scope may specify, for example, whether the credential specification is to be applied for one request, for requests from a particular user or client or group of users or clients, for requests for a designated time period, for a particular type of request, or for any combination of these parameters.

In addition, TAM **220** may be arranged to employ deep packet layer extractions based on a variety of rules to extract credentials, and/or other information that may be provided to another device, such as a controller, logger, server, or the like. For example, in one embodiment, TAM **220** may provide the credential to an LDAP server to enable access to additional resources by the requestor. In another embodiment, TAM **220** may receive additional credentials from an external authentication server in response to a query regarding the client.

Moreover, TAM **220** may receive rules, events criteria, or the like, from another device that enables TAM **220** to modify the specification of information that is extracted from a packet flow, the determinations to be performed, and the responses to be made based on the determinations. Thus, TAM **220** provides a convenient mechanism for dynamically modifying determinations and actions taken based on deep packet extractions of information in a packet flow. In one embodiment, TAM **220** may employ a process such as described below in conjunction with FIG. **3** to perform at least some of its activities.

AM **222** may include virtually any mechanism arranged to perform an authentication, authorization, and/or access determination, including a Pluggable Authentication Module (PAM), an Apache Authentication/Authorization/Access (AAA) module, or the like. Although AM **222** is illustrated as residing within network device **200**, the invention is not so constrained. For example, AM **222** may reside on another network device, without departing from the scope or spirit of the invention.

Generalized Operation

The operation of certain aspects of the invention will now be described with respect to FIG. **3**. FIG. **3** illustrates a logical flow diagram generally showing one embodiment of a process for managing access to a resource using deep packet credential extractions. Process **300** of FIG. **3** may be implemented within TMD **106** of FIG. **1**, for example.

Process **300** begins, after a start block, at block **302** when a request for a resource is received. Typically, the request is received over a network using TCP/IP, UDP/IP, or the like. In one embodiment, the request further employs HTTP; however, the invention is not so constrained. Moreover, the request may be associated with at least one network packet.

Processing continues to block **304**, where the received packet may be buffered, or otherwise stored in a temporary store. Processing flows next to block **306**, where credential criteria may be determined. It is important to note, that block **306** may also be performed prior to receiving a packet, or even concurrently, with receiving the packet. The credential criteria may be received from another device, such as a controller, a server, a system administrator, or the like. In one embodiment, the credential criteria includes an indication that username/password is to be evaluated to determine authorization to access the requested resource. In another embodiment, the credential criteria may include an indication to employ a digital certificate. Moreover, the credential criteria may indicate that information for the credential may be extracted from a cookie, from an OSI layer seven application payload such as an XML document, an HTTP form, obtained during a Secure Socket Layer (SSL) handshake, or the like. The credential and other information may be sought from a first layer and/or a second layer of the OSI layered protocol. For example, the credential and/or other information may be sought from buffered data that indicates the packet is a UDP packet and includes particular Network File System (NFS) application data or the like.

Moreover, in one embodiment, block **306** may also be configured to establish additional information that is to be extracted, such as information about the requestor's network address, or the like. Moreover, the credential criteria may be formatted using the deep-packet inspection rules syntax described above.

Process **300** flows next to block **308**, where the credential criteria are employed to inspect the buffered packet to extract credential information. Continuing to decision block **310**, a determination is made whether the buffered packet(s) include the sought credential information, and other additional information. The buffered data may not include the credential and/or other information for a variety of reasons. For example, the credential criteria may seek a specific data item, such as a specific HTTP cookie, or the like. HTTP cookies may span more than one packet. As such, additional packets may need to be buffered to determine whether the credential criteria, and/or other information are available. Thus, if it does not, processing branches to decision block **324**; otherwise, processing flows to block **312**.

At block **312**, the extracted credential information may be provided to an authentication module, including those described above. In one embodiment, the credential information may be provided to a plurality of authentication modules. How the information is provided may be dependent upon the interface with the authentication module. For example, in one embodiment, the information may be provided to the authentication module through a series of question/response ‘handshakes.’ Processing then flows to decision block **314**, where a determination may be made whether the authentication module received sufficient credential information to make a determination. This situation may arise, for example, where the authentication module seeks a particular input that was not available within a received packet. Thus, although, a credential may be been determined to have been received, at decision block **310**, it may not have been sufficient for the authentication module. In any event, if insufficient credentials are received, processing flows to decision block **326**; otherwise, processing flows to decision block **316**.

At decision block **316**, a determination is made whether a response from the authentication module indicates that the request is authenticated, authorized, and/or otherwise enabled for access to the requested resource. If the request is declined based on the determination, processing flows to block **334**; otherwise, processing continues to decision block **320**. In one embodiment, decision block **316**, may result in acknowledging a result of the determination, but still flow to decision block **320**, regardless of the results.

At decision block **320**, a determination is made whether to perform additional access determinations. Such determination may include any of a variety of activities. In any event, if more determination checks are to be performed, processing flows to block **330**; otherwise, processing flows to block **322**, where virtually any action may be performed based on accepting the request for access to the resource. Such actions may be dynamically determined, or even predetermined, and include, enabling access to the resource, sending the request to be load-balanced, or otherwise distributed to a selected server, or the like. In one embodiment, at least a portion of the credential and/or other information extracted from the flow of packets between the requestor may be provided to another device. In another embodiment, the request may be modified or replaced before it is sent to another device. This may include full proxying of TCP/IP or similar protocols; proxying between otherwise incompatible protocols; removing, encrypting, modifying, or obscuring sensitive credentials or other information in the client request. In yet another embodiment, such actions may also be taken on the responses being returned to the client. Upon completion of block **322**, process **300** may then return to a calling process to perform other actions.

At block **330**, additional access determinations, and/or other checks may be performed based on the credentials and/or additional information obtained. Processing next flows to decision block **332**, where a determination is made based on additional access determinations, and/or other checks whether to allow access to the requested resource. If access is to be allowed, processing flows to block **322**; otherwise, processing flows to block **334**.

Returning to decision block **310**, if it is determined that a credential is not obtained, processing flows to decision block **324**, where a determination is made whether to buffer more packet data from another packet in a flow of packets associated with the request. The determination to buffer more packet data may be based in part on an implicit determination. For example, where it is known that the credential criteria may span several packets, such as in application data, cookies, an SSL handshake that may span multiple communications and/or packets, or the like, process **300** may automatically decide to loop back to get a sufficient number of packets to be able to make an adequate determination that the credential and/or other information is received. Thus, if it is determined to seek more packets, process **300** loops back to block **302**; otherwise, processing flows to decision block **326**. In one embodiment, blocks **306**, **308**, and **310** are not explicitly used in the aforementioned loop. One or more of these steps may occur after some predetermined event, e.g., an HTTP request header block has been fully received and buffered.

At decision block **326**, a determination is made whether to provide a specific request for additional information. This may arise, for a variety of reasons. For example, it may be determined that some credential information is not provided unless it is specifically requested, or credential information might only be requested based on additional criteria not available early during communication with the client. If no more information is to be requested, processing flows to block **334**. However, if more information is to be requested, processing flows to block **328**, where the additional information is requested.

The request for additional information at decision block **326** may be at any of a variety of levels, including a web form, page, or the like, requesting information from an end-user. The request may also be at a lower OSI layer where the information may be provided through a network communication, or the like. In one embodiment, the request may result in a series of requests to be performed. In any event, upon completion of block **328**, processing loops back to block **302**.

At block **334**, any of a variety of actions may be performed as a result of declining the request, including providing a message to the requestor, denying access to the resource, providing a restricted access to at least a portion of the resource, redirecting the request to another resource, or the like. In one embodiment, at least a portion of the credential and/or other information extracted from the flow of packets between the requestor may be provided to another device. Upon completion of block **334**, the process may return to another process to perform other actions.

It will be understood that each block of the flowchart illustration, and combinations of blocks in the flowchart illustration, can be implemented by computer program instructions. These program instructions may be provided to a processor to produce a machine, such that the instructions, which execute on the processor, create means for implementing the actions specified in the flowchart block or blocks. The computer program instructions may be executed by a processor to cause a series of operational steps to be performed by the processor to produce a computer implemented process such that the instructions, which execute on the processor to provide steps for implementing the actions specified in the flowchart block or blocks.

Accordingly, blocks of the flowchart illustration support combinations of means for performing the specified actions, combinations of steps for performing the specified actions and program instruction means for performing the specified actions. It will also be understood that each block of the flowchart illustration, and combinations of blocks in the flowchart illustration, can be implemented by special purpose hardware-based systems which perform the specified actions or steps, or combinations of special purpose hardware and computer instructions.

The above specification, examples, and data provide a complete description of the manufacture and use of the composition of the invention. Since many embodiments of the invention can be made without departing from the spirit and scope of the invention, the invention resides in the claims hereinafter appended.

What is claimed as new and desired to be protected by Letters Patent of the United States is:

1. A network device for managing a communication between a client and a server, comprising:
- a transceiver that receives packets from the client; and
- a processor programmed to perform actions including:
  - receiving from the client a request for a resource;
  - dynamically changing criteria that indicates what credential information is to be extracted from a packet flow using deep packet inspection rules and what credential information is to be evaluated to determine whether the request is authorized;
  - extracting the credential information based on the dynamically changed criteria from at least one packet in the packet flow associated with the request;
  - determining that the extracted credential information is insufficient to determine whether the request is authorized and based on the determination, automatically sending a query to the client for additional information to be received in one or more subsequent packets from the client in response to the query;
  - when the additional information and the extracted credential information are affirmatively authenticated, requesting different credential information based on the dynamically changing criteria; and
  - selectively allowing access to the requested resource based on authorization of the different credential information.

2. The network device of claim **1**, wherein the processor programmed to perform actions, further including:
- determining whether the access to the resource is authorized based additionally on at least one of a type of client device associated with the request, a security software on the client device and security parameters set for the software, a time of day of the request, a type of request, or a number of time the requested resource has been accessed within a tune period.

3. The network device of claim **1**, wherein selectively allowing access further comprises at least one of flagging the request tor additional processing, performing verbose logging, or performing intrusion detection analysis on the request.

4. The network device of claim **1**. wherein dynamically changing criteria indicating what credential information is to be evaluated further comprises receiving at least one conditional command and event control instruction.

5. The network device of claim **1**, wherein dynamically changing criteria further comprises dynamically receiving the changed criteria from a controller based on the controller detecting suspicious activity and sending the criteria to vary a level of credential checks to be performed by the network device.

6. The network device of claim **1**, wherein dynamically changing criteria further comprises receiving a request from a controller requesting that the credential information be provided to the controller.

7. The network device of claim **1**, wherein the processor programmed to perform actions, further including:
- based on a determination that the request is allowable, selecting at least one server based on a rule associated with the allowed access, and directing the request to the selected server.

8. A system, comprising;
- a memory storage device having stored thereon protected content; and
- one or more processors programmed to perform actions, including:
  - receiving a request from a client for at least some of the protected content;
  - dynamically changing criteria that indicates what credential information is to be extracted from a packet flow using deep packet inspection rules and what credential information is to be evaluated to determine whether the request is authorized;
  - extracting the credential information based on the dynamically changed criteria from at least one packet in the packet flow associated with the request;
  - determining that the extracted credential information is insufficient to determine whether the request is authorized and based on the determination, automatically querying the client for additional information to be sent by the client in one or more subsequent packets in response to the query; and
  - when the additional information and the extracted credential information are affirmatively authenticated, requesting different credential information based on the dynamically changing criteria; and
  - selectively allowing access to the requested protected content based on authorization of the different credential information.

9. The system of claim **8**, wherein the one or more processors is programmed to perform actions further including:
- determining whether the access to the protected content is authorized based additionally on at least one of a type of client device associated with the request, a security software on the client device and security parameters set for the software, a time of day of the request, a type of request, or a number of time the requested protected content has been accessed within a time period.

10. The system of claim **8**, wherein selectively allowing access further comprises at least one of flagging the request tor additional processing, performing verbose logging, or performing intrusion detection analysis on the request.

11. The system of claim **8**. wherein dynamically changing criteria indicating what credential information is to be evaluated further comprises receiving at least one conditional command and event control instruction.

12. The system of claim **8**. wherein dynamically changing criteria further comprises receiving the criteria from a controller based on the controller detecting suspicious activity and sending the criteria to vary a level of credential checks to be performed by the network device.

13. The system of claim **8**, wherein the processor programmed to perform actions including:

based on a determination that the request is allowable, selecting at least one server based on a rule associated with the allowed access, and directing the request to the selected server, wherein the protected content is accessed through the selected server.

14. A method, composing:

employing one or more servers for providing access to content; and

employing one or more processors to perform actions, including:

receiving a request for at least some of the content;

dynamically changing criteria that indicates what credential information is to be extracted from a packet How using deep packet inspection rules and what credential information is to be evaluated to determine whether the request is authorized;

extracting the credential information based on the dynamically changed criteria from at least one packet in the packet flow associated with the request;

determining that the extracted credential information is insufficient to determine whether the request is authorized and based on the determination, automatically sending a query to the client for additional information to be received in one or more subsequent packets from the client in response to the query; and

when the additional information and the extracted credential information are affirmatively authenticated, requesting different credential information based on the dynamically changing criteria; and

selectively allowing access to the requested content based on authorization of the different credential information.

15. The method of claim **14**, wherein the one or more processors are programmed to perform actions, further including:

determining whether the access to the content is authorized based additionally on at least one of a type of client device associated with the request, a security software on the client device and security parameters set for the software, a time of day of the request, a type of request, or a number of time the requested content has been accessed within a time period.

16. The method of claim **14**, wherein selectively allowing access further comprises at least one of flagging the request for additional processing, performing verbose logging, or performing intrusion detection analysis on the request.

17. The method of claim **14**, wherein dynamically changing criteria indicating what credential information is to be evaluated further comprises receiving at least one conditional command and event control instruction.

18. The method of claim **14**, wherein dynamically changing criteria further comprises receiving the criteria from a controller based on the controller detecting suspicious activity and sending the criteria to vary a level of credential checks to be performed by the network device.

19. The method of claim **14**, wherein selectively allowing access further comprises causing a communication between a client requesting the content and a server providing the content to he encrypted al a different grade of encryption than currently employed with the client.

20. The method of claim **14**, wherein the one or more processors are programmed to perform actions, further including:

based on a determination that the request is allowable, selecting at least one server in the one or more servers based on a rule associated with the allowed access, and directing the request to the selected server.

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